

**STUDIES ON THE NATURE AND CHEMISTRY OF SEDIMENTS
AND WATER OF PERIYAR AND CHALAKUDY RIVERS,
KERALA, INDIA**

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**DOCTOR OF PHILOSOPHY
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By

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CERTIFICATE

This is to certify that this thesis work entitled “**STUDIES ON THE NATURE AND CHEMISTRY OF SEDIMENTS AND WATER OF PERIYAR AND CHALAKUDY RIVERS, KERALA, INDIA**” is an authentic record of the research work done by **MAYA. K**, under my scientific supervision and guidance, for the partial fulfilment and the requirement for the Degree of Doctor of Philosophy of the Cochin University of Science and Technology. No part of it has been previously formed the basis for the award of any degree, diploma or associateship in any other University.



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PREFACE

Among various geological agents at work, rivers have been receiving special attention from the beginning of mankind. Rivers are the chief carriers of water, dissolved salts and organic matter from land to the sea. They are the prime architect in shaping the geomorphic features of tropics and subtropics. The natural channels and flowing waters that form the essential components of rivers act as corridors for the free movement of organisms among various aquatic ecosystems. But, it is unfortunate that, increased human interventions consequent to economic development in the past 3- 4 decades have imposed tremendous pressure on these life support systems. Recent studies reveal that human interventions have caused world-wide increase in river input of geochemical constituents, especially nutrient elements, to the coastal ecosystem by many folds. This in turn leads to imposed eutrophication incidences in many parts of the coastal areas. Construction of dams / reservoirs and associated structures, on the other hand, causes considerable reduction in the supply of water and sediments downstream, thereby affecting the natural river processes and also its stability. The scenario is being complicated further by the huge discharge of toxic contaminants from point and non-point sources. As a result of all these interventions / processes, the river systems of tropics and sub-tropics have been altered to levels often beyond their natural productive capacity.

Kerala State is blessed with 44 small rivers with catchment area <10000 km². Estimates show that these rivers together transfer about 78000 million m³ of water into the Lakshadweep Sea every year. Uncontrolled discharge of pollutants from urban, agricultural and industrial sources, indiscriminate mining of construction materials (clay and sand) from instream and floodplain areas, damming of rivers, inter-basin water transfer, etc., have adversely affected the natural processes of these river systems. The

recurring incidences of fish diseases and ecosystem disorders are nothing but the signals of man-imposed stresses in these ecosystems, which obviously need immediate attention and corrective measures.

The present study is an attempt to address issues related to sediment properties like texture, mineralogy and geochemistry as well as water quality of two important rivers of central Kerala – the Periyar (River length : 244 km, Catchment area : 5398km²) and the Chalakudy (River length 130 km, catchment area 1704 km²) rivers. These river basins are located between North latitudes 9^o15'50" & 10^o32'53" and East longitudes 76^o7'38" & 77^o24'32".

The entire thesis is addressed in seven chapters. Chapter 1 comprises the general introduction of the study area with its location, drainage, river discharge, physiography, geology, structure, climate, landuse, population, environmental degradation and the objectives of the study. The various methods employed in the study, consisting of fieldwork, sampling, laboratory investigation and computation of data are presented in Chapter 2. Chapter 3 deals with textural characteristics like, grain size and statistical parameters, bivariate plots, CM pattern and classification of sediments. Mineralogical parameters such as heavy mineral assemblage and correlation matrix of heavy minerals etc. are incorporated in Chapter 4. Chapter 5 is devoted to geochemistry and pollution assessment using statistical parameters like enrichment factor and contamination factor. Chapter 6 deals with a detailed analysis of water quality and nutrient fluxes of these rivers. The summary and conclusions of this study are dealt in Chapter 7. The relevant literature cited is given at the end of the thesis.

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CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

Rivers are the major geological agents in tropical and sub-tropical regions. Year by year, rivers transport about 37000 km³ of water (Meybeck, 1976) and 13.5 x 10⁹ tonnes of sediments (Milliman and Meade, 1983) from terrestrial environments to the world oceans. During transportation, water and sediments undergo considerable changes in their physico-chemical properties depending on terrain characteristics and climate of the region through which the river flows (Gibbs, 1977a; Lal, 1977; Subramanian, 1979; Sajjan et al., 1992; Walling, 1999; Somayajulu et al., 2002; Ankers et al., 2003; Turner and Rabalais, 2004). It is now well understood that river transport of particulates, nutrients and minerals plays a major role in maintaining the productivity of the coastal and the nearshore environments of the world. Rivers and its estuaries provide connectivity between terrestrial and marine environments and also act as corridors for free movement of aquatic organisms among various sub-environments. But, unfortunately, increased human interventions consequent to the economic development in recent years have imposed tremendous pressure on the river systems. Several studies reveal that human interventions have caused worldwide increase in river input of geochemical constituents, especially nutrient elements to the coastal ecosystem by many folds leading to 'imposed eutrophication' incidences in many parts of the coastal areas. Construction of engineering structures like dams, spillways etc. are also responsible for changes in natural processes of river environments. The scenario is being complicated further by the huge discharge of toxic contaminants from point and non-point sources. All

these, in one way or the other, have negatively affected the natural productive capacity of these life support systems of tropics and sub-tropics.

The situation is not so different in the river systems of Kerala, especially in the Periyar and Chalakudy rivers draining, respectively, the industrial and cultural capitals of the State. Discharge of pollutants from urban, agricultural and industrial sources, indiscriminate mining of construction grade materials (clay and sand) from instream and floodplain areas, damming of rivers, inter-basin transfer of water etc., have adversely affected the natural processes of these river systems. The recurring incidences of fish diseases and ecosystem disorders are signals of man-imposed stresses in these ecosystems, which obviously need immediate attention and corrective measures based on careful observations and studies.

The present study is an attempt to address certain aspects of the sediment and water systems of the Periyar and the Chalakudy rivers flowing through Idukki, Ernakulam and Thrissur districts of Kerala. The study includes a systematic analysis of sediment properties like texture, mineralogy and geochemistry and also the quality of overlying waters of these river systems. An attempt has also been made to evaluate the pollution status of the area.

1.2 STUDY AREA

1.2.1 Location

The area selected for the present study, the Periyar and Chalakudy river basins, falls within the central part of Kerala (Fig.1.1) and lies between North latitudes $9^{\circ}15'50''$ - $10^{\circ}32'53''$ and East longitudes $76^{\circ}07'38''$ - $77^{\circ}24'32''$. The area spreads in the Idukki, Ernakulam and Thrissur districts and comprises 16 taluks – 5 in Thrissur, 7 in Ernakulam and 4 in Idukki.

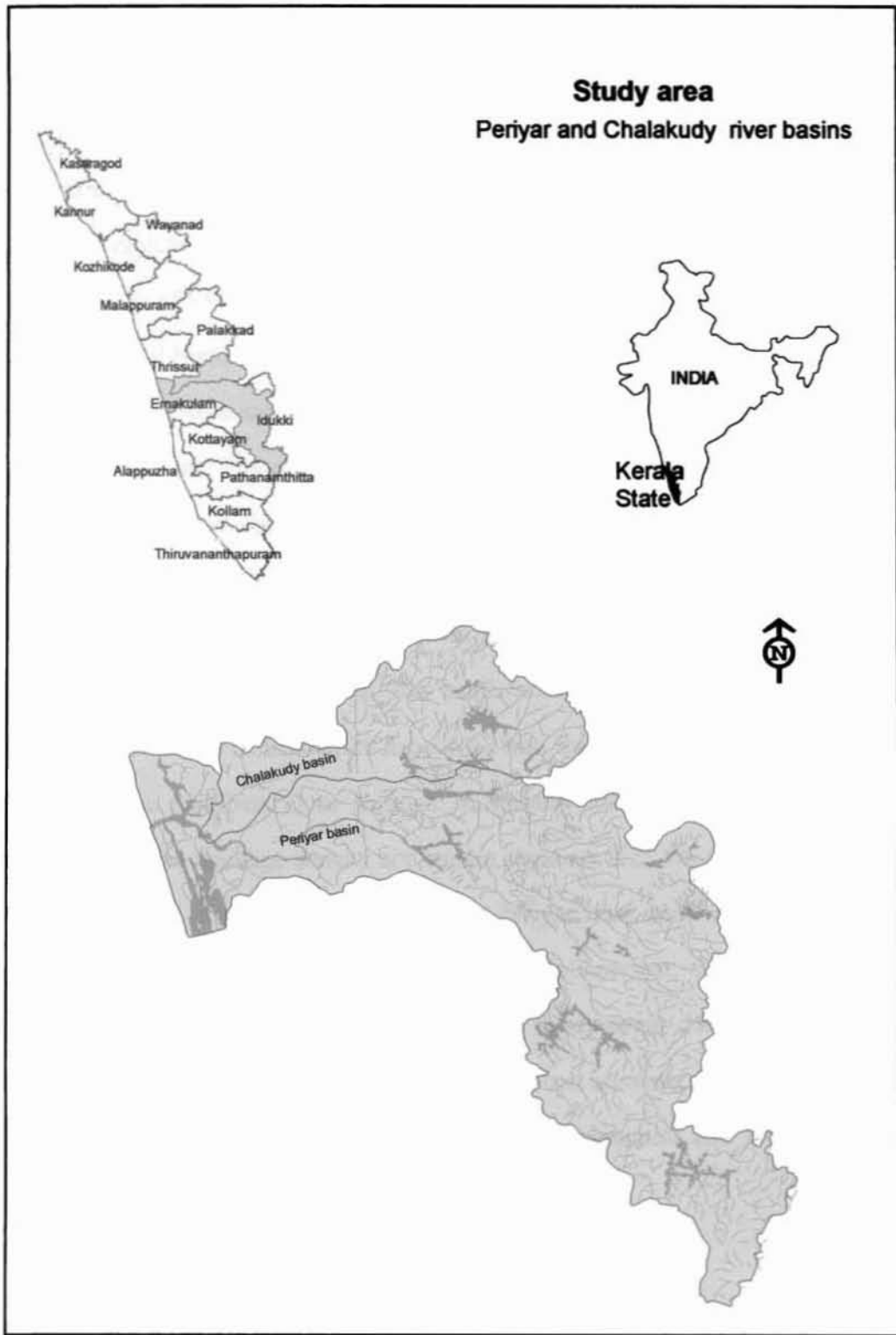


Fig. 1.1 Location map of the study area

1.2.2 Drainage

Periyar river

The Periyar river other wise called the *Poorna nadi*, is the longest river of Kerala and also the largest in water discharge potential (Kerala State Gazetteer, 1986). Fig 1.2 depicts the drainage characteristics of the river which has a length of about 244 km and a catchment area of 5398 km²; out of which a total of 5284 km² lies in the Kerala State and rest in the Tamil Nadu State. The river originates from the Sivagiri hills at an elevation of about 1830 m above mean sea level (msl) and flows through highly varied geologic and geomorphic regions. The major channel supplying water and sediments to Periyar river are the Muthirapuzha, Perinjankutty, Edamalayar and Mangalampuzha tributaries. The river bifurcates near Aluva township into two major distributaries: the southwesterly branch is called as the Marthanda Varma distributary (flowing through Eloor-Kalamassery industrial belt) and the northwesterly branch as the Mangalapuzha distributary. Both the distributaries debouches into the Lakshadweep Sea either directly (Mangalapuzha distributary) or through backwaters (Marthanda Varma distributary); (Annexure I). The drainage density and stream slope are 0.21 km / km² and 7.14 m / km, respectively. The important reservoirs in the Periyar river basin are Bhoothathankettu, Idukki, Lower Periyar, Kallarkutti, Ponmudi, Mullaperiyar, Mattupetti, Anayiragal, Kundla and Idamalayar. Table 1.1 summarises the relevant details of some of these reservoirs whose information is available in published accounts. The longitudinal profile of the river is depicted in Fig. 1.3a. The river is perennial and generally exhibit a dendritic drainage pattern.

Chalakydy river

The Chalakydy river is a comparatively smaller perennial river than the Periyar. Though Chalakydy river in strict geological sense is a tributary of Periyar river, for all

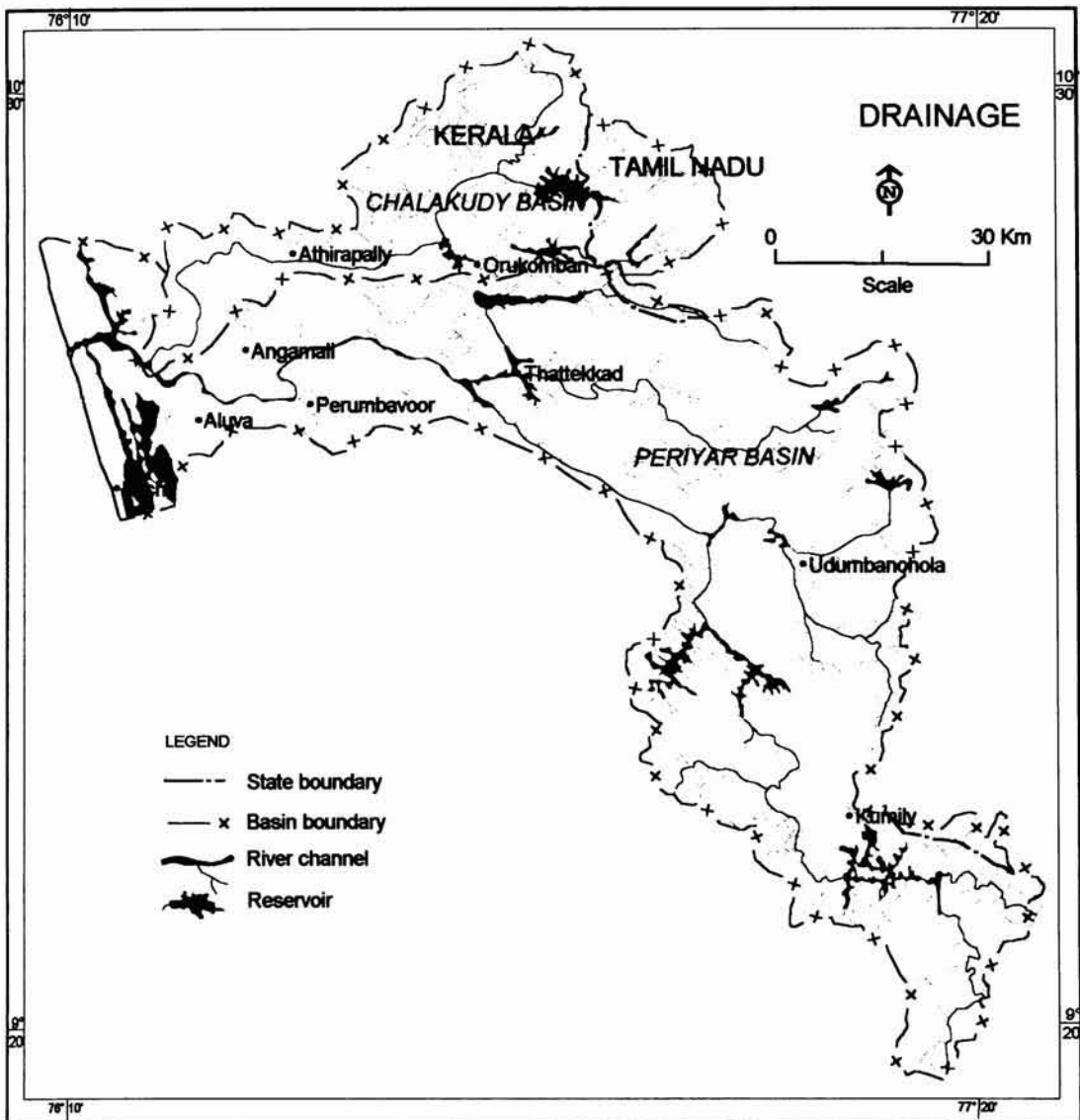


Fig. 1.2 Drainage map of the study area (Periyar and Chalakudy river basins)

Table 1.1 Important reservoirs in the Periyar and Chalakudy river basins

Sl. No.	Name of Reservoir	Year of completion	Height of dam (m)	Length (m)	Volume of content ($\times 1000\text{m}^3$)	Reservoir			Designed spill way capacity (m^3/s)
						Area at FRL (km^2)	Gross capacity (million m^3)	Effective capacity (million m^3)	
I PERIYAR RIVER BASIN									
1	Kundala	1946	32.30	259	54	0.47	7.79	7.65	184.06
2	Mattupetty	1956	85.34	237	155	3.24	55.23	55.23	-
3	Sengulam	1957	26.80	144	18	0.29	0.71	0.71	70.80
4	Kallarkutty	1961	43.00	183	40	0.65	6.88	6.51	1982.40
5	Ponmudy	1963	59.00	294	181	2.79	51.54	47.40	1416.03
6	Anayirangal	1965	34.00	292	462	4.86	49.84	48.99	348.00
7	Idukki	1974	168.90	366	46	59.83	1996.30	1459.50	5100.50
8	Cheruthoni	1976	138.20	650	1700	59.83	1996.30	1459.50	5100.50
9	Kulamavu	1977	100.00	385	450	59.83	1996.30	1459.50	5100.50
10	Idamalayar	1985	12.20	58	4	0.25	0.79	0.77	1014.00
11	Kallar	1989	20.00	146	16	0.97	5.35	5.09	507.00
12	Erattayar	1989	102.80	373	880	28.30	1089.80	1017.80	3012.80
13	Lower Periyar	1995	39.00	244	140	0.45	5.30	4.50	14200.00
II CHALAKUDY RIVER BASIN									
1	Peringalkuttu	1957	36.90	366	63	2.85	32.00	30.30	2266.00
2	Sholayar- Maindam	1965	66.00	430	303	8.71	153.60	15.20	1825.00
3	Sholayar- Flanking	1964	28.00	259	44	8.71	153.60	15.20	1825.00
4	Sholayar-saddledam	1965	19.00	109	18	8.71	153.60	15.20	1825.00

Source: KSEB (1996), FRL- Full Reservoir Level

